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GENDER AND SCIENCE IN EDUCATION

Frank Ventura

Interest in gender and subject choice derives mainly from two concerns: equality between the sexes, which focuses on the need to avoid sexual discrimination in education; and the shortage of female representation in certain fields of higher education, particularly in scientific and technical areas. In the fields of science and mathematics education, these concerns have given rise to a body of research which goes back to the late 1960s and early 1970s. In the United States of America, the initial focus was on sex differences in performance but this soon widened to include the factor of differences in the choice of courses.[1] In Britain, similar research in the 1970s and early 1980s concentrated on the under-representation of girls in science education and possible causes for it. Results showed that in 1974 boys outnumbered girls in studying physics at Ordinary level 4:1, at CSE level 8:1, and in chemistry 2:1. However girls outnumbered boys 2:1 in biology.[2]

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1 KAMINSKY, D.M., 'Girls and Mathematics and Science. An Annotated Bibliography of British Work (1970-1981)', *Studies in Science Education*, 9 (1982), pp. 81-108.

2 See GANNON, C., 'Girls' Underachievement in Science', *CORE* 4(1) (March 1980) fiche 17; and HARDING, J., 'Sex Differences in Science Examinations' in KELLY, A.(ed.), *The Missing Half: Girls and Science Education*, (Manchester University Press, Manchester 1981), pp. 192-204.

More recent British research shows that science option choices are still sex-stereotyped even in schools where an intervention programme entitled GIST (Girls in Science and Technology) was operating. In fact, in the GIST schools, physics was chosen by fifty-one per cent of the boys and only twenty-one per cent of the girls; biology by twenty per cent of the boys and fifty-one per cent of the girls, while the combined figures for biology and human biology were twenty-five per cent for boys and sixty-one per cent for girls; chemistry was chosen by thirty-two per cent of the boys and thirty-one per cent of the girls.[3] In 1984 a national survey on the assessment of performance in science at the age of fifteen undertaken in England, Wales and Northern Ireland produced very similar results.[4] Interestingly, however, between 1980 - 1984 an increase in preference for the sciences was noted, especially physics and chemistry among girls, and this was not at the expense of biology.[5]

Investigations of causal variables generally follow Curran's suggestion that what needs to be explored is whether females (i) can't do science, (ii) aren't allowed to (overtly or covertly), or (iii) don't want to.[6] The question of ability is indeed very important since channeling of pupils of different abilities is prevalent, with the more able channeled to science, while the less able are channeled out. [7] The manifest inferiority of girls in spatial ability

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3 KELLY, A., 'The Customer is Always Right ... Girls' and Boys' Reactions to Science Lessons', *School Science Review*, no. 69 (1988), pp. 662-676.

4 See JOHNSON, S. & MURPHY, P., 'Girls and Physics', APU Occasional Paper no. 4, (Department of Education and Science, London 1986).

5 JOHNSON, S. & BELL, J.F., 'Gender Differences in Science: Option Choices', *School Science Review*, no. 69 (1987) pp. 268-276.

6 CURRAN, L., 'Science Education: Did She Drop Out or Was She Pushed?' in BIRKE, L. et al. (eds), *Alice Through the Microscope: The Power of Science Over Women's Lives*, (Brighton Women and Science Group, Virago, London 1980) pp. 22-41.

7 See KELLY, A., 'Sex Differences in Science Achievement: Some Results and Hypotheses' in KELLY, A.(ed.), *The Missing Half*, op. cit., pp. 22-41; and JOHNSON, S. and BELL, J.F., op. cit.

has occasionally been given as a reason why girls show a lower ability in science but the connection between the two is not strong.[8] Various overt and covert factors that are thought to influence subject choice have been investigated including (i) the masculine character of physics, chemistry and technology which is reinforced by sex-stereotyping in textbooks and the media; (ii) classroom interactions in mixed classes which tend to favour boys and which are exploited by them; (iii) differential early science experiences through which boys preferentially gain scientific skills and confidence in tackling problems.[9] The extent of the influence of each factor is not known, but for example Johnson and Murphy suggest that the root of the problem of the girls' underachievement in physics at secondary school level lies in the differences in early socialization experiences rather than in other factors.[10] Other researchers suggest that the different attitudes to science of boys and girls has more influence than other factors. Thus, reviewing the literature on attitudes towards science, Gardner and Schibeci agree that of the myriad variables which are possible influences on attitudes, sex is a consistently significant variable in many studies.[11] Generally, boys display a considerably more favourable attitude towards science but there are differences in the nature of boys' and girls' scientific interests, boys showing greater interest in physical science activities while girls are more interested in biological and social science topics. These differences are consistent with the choice of subjects and both Gardner and Schibeci contend that the often substantial attitudinal differences between the sexes suggest that attitudes are more important than cognitive factors in accounting for subject choice.

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8 JOHNSON, S. & MURPHY, P., 'Girls and Physics', op. cit.

9 KELLY, A., 'Sex Differences...', op. cit.

10 JOHNSON, S. & MURPHY, P., 'The Underachievement of Girls in Physics: Towards Explanations', *European Journal of Science Education* vol. 6 no. 4, (1984) pp. 399-409.

11 GARDNER, P.L., 'Attitudes to Science: A Review', *Studies in Science Education*, 2 (1975) pp. 1-41; SCHIBECI, R.A., 'Attitudes to Science: An Update', *Studies in Science Education*, 11 (1984) pp. 26-59.

THE MALTESE EDUCATIONAL CONTEXT

But are American and British research findings relevant to Malta? The answer to this question depends on whether the major factors influencing subject choice are due to inherent differences between boys and girls and to socialization, or principally due to the formal educational context. If the major influence depends on the educational context, then USA and UK findings are probably not relevant to Malta because the Maltese context is significantly different on a number of important factors. Some of these factors have a direct influence on subject choice while others contribute in an indirect way. The first factor, and one which has only an indirect influence, is the existence of examinations at the end of primary schooling to select the more able pupils for entry either to government junior lyceums (academic grammar schools) or to private secondary schools, which to a certain extent are equivalent to junior lyceums. The effect of these examinations has not been properly investigated but success or failure is bound to affect pupils' perceptions of their abilities and consequently their future career aspirations and subsequent subject choice. The selective system may in fact be preventing many from the later pursuit of abilities by restricting far too soon and far too narrowly the choices open to pupils, as had happened in the UK when pupils were similarly selected at 11+.[12] The second factor, and also one which has an indirect influence, is that a high proportion of students are creamed off to private secondary schools. The latest published figures show that in October 1987 there were 6513 students in private secondary schools.[13] These constituted 24.9% of the secondary level population, that is pupils in junior lyceums, government and private secondary schools and in trade schools. This factor is expected to have a greater influence on boys than on girls since more boys (28.8%) than girls (20.8%) attend private schools. The third factor is that the management of government schools is highly centralized such that schools' curricula, subject options on offer and the process of subject choice is determined fairly rigidly. This state of affairs ensures uniformity, though

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[12] HIRST, P.H., 'Ethical Considerations in Selection and Streaming', *Education*, vol. 3 no. 3 (Malta 1989) pp. 2-8.

[13] *Workings of the Education Department*, 1st January 1987 to 31st December 1987 (Department of Education, Malta 1988).

heads of schools sometimes use their discretion to give students a more flexible choice of subjects.[14] A fourth factor which makes secondary schools in Malta different from those in the UK and USA is that they are all single-sex schools, whether government or private. UK research indicates that girls in single-sex schools are at an advantage with respect to their counterparts in mixed schools as far as choice of science subjects is concerned.[15] Thus one expects to find proportionately more girls opting for science in Malta than in other countries where mixed secondary schooling is predominant. A fifth factor is that except for trade schools the curricula of which are largely determined by the needs of the various trades, the secondary school curriculum of both government and private schools is based on the requirements of GCE Ordinary level syllabuses. This means that pupils of a very wide range of ability are expected to follow syllabuses which are meant for the top twenty-five per cent. The prospect of having to follow a science course which is not matched to the pupils' ability militates against its wide adoption.

Considering these differences in the educational contexts, it is not valid to assume that the research results obtained abroad automatically apply to Malta, unless one also assumes that the major factors contributing to subject choice are intrinsic differences between boys and girls, and socialization factors both of which are, to a large extent, independent of the formal educational context.

The main purpose of this paper is to describe how the choice of science is made at secondary level in Malta, to discuss some factors that may be affecting subject choice, to describe trends in science choice, and to evaluate any differences in achievement between boys and girls. It would then be possible to make a valid comparison with USA and UK results and also to obtain an estimate of the degree of influence of the educational context on subject choice.

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14 MERCIECA, M.R., 'Factors Influencing Subject Choice and Choice Satisfaction', paper presented as part requirement for the award of the Diploma in Guidance and Counselling, (Faculty of Education, University of Malta 1987).

15 SARAH, E., SCOTT, M. & SPENDER, D., 'The Education of Feminists: The Case for Single-sex Schools', in SPENDER, D. & SARAH, E. (eds), *Learning to Lose: Sexism and Education*, (The Women's Press, London 1980) pp. 55-66.

The data on school options and subject choice were obtained from the government schools' quarterly returns to the Department of Education. The Test Construction Unit of the Department of Education provided the results of the national annual examinations while the GCE Ordinary level results were obtained from the Examinations Branch of the Ministry of Education. Data about private schools were taken from the Private Schools Project which was conducted by Mary Darmanin and Frank Ventura.[16]

MAKING A CHOICE

At the end of the primary level, pupils normally go to a secondary school. For the first two years practically all pupils in government and private schools follow a common curriculum. This includes integrated science which takes up slightly less than twelve per cent of the time. The major difference between boys and girls at this stage is that while girls are taught home economics and needle-craft, boys are offered craft courses. Normally, after two years in the secondary school, pupils are asked to make two important decisions concerning their future careers. They are first asked whether they want to stay on in a secondary school or junior lyceum and follow an academic course, or whether they prefer to go to a trade school in order to follow a vocational course. Those who opt for an academic course are further asked to choose two subjects to specialize in, and consequently to drop other subjects.

Boys opting to go to a trade school follow a common course for one year after which they are guided to select a trade which is most suitable for their aptitude. Trade school girls have a much narrower choice of options and almost all of them follow a common three year course which aims at developing their needle-craft skills. All first year trade school pupils follow a common general science course which deals mainly with very simple physical science concepts. After that, the amount of science covered by trade school pupils depends very much on the trade they choose. Thus students opting for an electrician's course do more science than others opting for a plumber's course. Since girls usually

[16] see DARMANIN, M., 'Gender Differentials and Subject Choice in Maltese Secondary Schools', in this volume.

carry on with needlecraft trades, no specific science course is offered to them after the first year.

Subject choice in the secondary school is made at the end of the second year, except for two or three private schools which postpone the choice to the end of the third year. In government schools a common procedure is adopted. Pupils are asked to select two subjects from five blocks entitled Languages, Sciences, Commerce, Art and General. But, it has been reported that some heads of schools use their discretion and offer a more flexible choice to their students.[17] Choices that include science subjects are restricted to biology and chemistry, chemistry and graphical communication (taken by boys), and biology and home economics or needlecraft (taken by girls). Besides the optional subjects, all government school pupils study Maltese, English, mathematics, religion, social studies, physics, physical education and one or two languages as core subjects.

This range of core subjects and option blocks may be different once the National Minimum Curriculum (Secondary Level) is implemented.

Guidance teachers hold general meetings and meetings on an individual basis to assist pupils and their parents in several ways. Pupils are administered a career interest test developed by the Guidance and Counselling Unit of the Education Department. Information is gathered about the pupils' abilities, interests and aptitudes. With the results of the career interest test, data about each individual's performance, and information about careers and required qualifications, guidance teachers are well prepared to give good advice. The procedure is rather complicated but it gives positive results as shown by a study of the whole population (N=265) of Form 4 girls in a junior lyceum carried out in November 1986[18] which indicated that the great majority of pupils were satisfied with their subject choice.

Private schools offer a narrower range of options but a wider spectrum of compulsory subjects. The options are offered as blocks which vary between schools but which usually consist of (i) Sciences: biology and chemistry; (ii) Commercial subjects:

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[17] MERCIECA, M.R., 'Factors Influencing Subject Choice...', op. cit.

[18] ibid.

commerce, accounting, economics and sometimes typing and shorthand for girls; (iii) Arts: including history and geography. All six private schools covered by the Private Schools Project had a sciences and commerce option on offer, while four of them also provided a general or arts option. These schools helped pupils and advised parents about the choice of options but they did not have the elaborate scheme operating in government schools because there was no formal set-up of guidance teachers in the schools. The choice of subjects usually depended on the pupils' performance in the examinations at the end of the second year. Regarding the choice of sciences, private schools usually restricted the option to those pupils who performed very well in mathematics and in general science in the first two years. The most explicit reference to these conditions was found in the choice application form of a girls' private school which contained the following requirements:

> Pupils choosing science subjects must obtain seventy per cent in Mathematics and General Science; pupils choosing Economics and Accounts must obtain seventy per cent in Mathematics and sixty per cent in English; pupils choosing Shorthand must obtain sixty per cent in English.

INFLUENCES ON SUBJECT CHOICE

From the previous section, it should be clear that the pupils' choice of subject depends on their ability in the subject and in other subjects related to it. But a number of other factors may influence the choice, foremost among which is the pupils' attitude towards the subject. Studies in many countries show that science is a subject which is initially liked by many students but which unfortunately becomes to be disliked and discontinued.[19] The decline in interest is found to be sharper in science than in other subjects. Gender differences related to interest in science are also found in many countries. Males are generally more interested in science than females and there are distinct differences in the patterns of scientific interest of males and females. Males are

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[19] GARDNER, P.L., 'Students' Interest in Science and Technology: An International Overview', in LEHRKE, M., HOFFMAN, L. & GARDNER, P.L. (eds), *Interests in Science and Technology Education* (Institute for Science Education [IPN], Kiel, Federal Rep. of Germany 1985) pp. 15-34.

more likely to be interested in the physical sciences, technology and practical aspects while females are more likely to be interested in biology and the social aspects and implications of science.[20] These differences are expected to give rise to gender differences in subject choice.

As far as Maltese pupils are concerned, a questionnaire on differences in attitudes towards science, administered to a random sample of 363 Form 2 government secondary school pupils (157 boys and 206 girls) from nine schools in June 1983 provided some information about the pupils' interest in science at the end of their second year.[21] The questionnaire consisted of eighteen items divided into three scales relating to interest in science, difficulty and relevance. The average global score of boys and girls was practically identical, 66.7%, indicating an equal, moderately positive attitude toward science. However, mean scores (X) on the interest scale showed that boys were significantly more interested in science than girls (X boys = 81.9%, X girls = 76.1%, $p<.001$). On a particularly significant item of the interest scale, 27.7% of the girls agreed that they will drop science at the first opportunity, however only 15.9% of the boys gave the same negative response. There were no significant differences on the difficulty scale (X boys = 50.8%, X girls = 51.8%), and on the relevance scale (X boys = 64.0%, X girls = 64.9%). There were however significant differences on particular items. Thus 33% of the boys thought that science was more suitable for boys than for girls, while only 6.3% of the girls thought likewise. Another item showed that the majority of girls, 54.4%, as against only 43.9% of the boys thought that learning a language was better than learning science. These results showed that interest in science was not low, but boys were more interested in the subject than girls. From the responses, it was expected that fewer girls would opt for science subjects.

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[20] see SCHIBECI. R.A., 'Attitudes to Science...', op. cit., and GARDNER, P.L., 'Student' s Interest ...' , op. cit.

[21] VENTURA, F., *An Evaluation of the Science Curriculum in the First Two Years of the Area Secondary School in Malta,* unpublished M.Phil. Dissertation, (University of Reading, U.K. 1985).

A more direct indication of the factors that influence subject choice was obtained from an item in the Private Schools Project survey which asked pupils to indicate reasons for their choice of subjects. A list of reasons was provided and pupils were invited to mark any number of items. The results, shown in Table 1, were analysed globally and also separately by sex and by option (Science and non-Science).

TABLE 1
Reasons for the choice of subject option by a sample of boys and girls attending private schools in 1989-1990

	BOYS			GIRLS		
	Sc. N=146	Non-Sc. N=204	Total N=350	Sc. N=93	Non-Sc. N=140	Total N=233
a. I liked the subjects	128	162	290	83	114	197
b. I am good at these subjects	101	97	198	39	53	92
c. My parents wanted me to choose them	24	25	49	9	12	21
d. My sister/brother chose them	14	18	32	2	6	8
e. I like the teacher of this subject	21	16	37	2	16	18
f. My teacher encouraged me	18	13	31	3	7	10
g. My counsellor encouraged me	13	28	41	1	4	5
h. My friends chose them	13	19	32	3	6	9
i. They are related to the course / job I would like	129	162	291	80	109	189

The global results showed that the three most popular reasons given by private school pupils for choosing particular subjects were: (i) because pupils like them (83.5%); (ii) because the subjects were seen as related to the future job/course they would like to follow (82.3%), and (iii) because they were good at the subjects (49.7%). These results agreed with those obtained from a survey of 265 Form 4 girls in a junior lyceum who gave the following reasons for their choice of subjects: the subjects were interesting (85%); they were useful for their future career (82%); good performance in the

subjects (37%); the chosen subjects were easy (32%); parental influence (9%); congenial teacher (9%), and peer influence (3%).[22]

When the results in Table 1 were analysed by option, there were no significant differences in the reasons for the choice given by science and non-science pupils of either sex. However, when an analysis by sex was carried out, although the rank order of the reasons given by boys and girls was practically the same, there were significant differences in the proportions of boys and girls giving particular reasons. These differences were very highly significant (χ^2=33.19, p<.001) between all the boys and girls in the sample and between the science boys and girls (χ^2=23.84, p<.001). There was also a difference between the non-science boys and girls but this was less significant (χ^2=17.47, p<.05).

The major sex difference was that reason (b) i.e., 'I am good at these subjects' was much more often chosen by boys than by girls perhaps indicating a lower self-esteem on the part of the girls. This difference was most obvious between science pupils but it was also present between non-science pupils of different sex. Another difference was that while girls tended to focus on a few reasons (mostly reasons a, b and i), boys quoted a variety of reasons for their choice. Surprisingly, a much higher proportion of boys than girls gave reasons related to the influence of the teacher on their choice (reasons e and f). Usually, the teacher factor was thought to influence girls more than boys. Another difference to note was that more boys than girls chose reason (c) possibly revealing a greater parental interest in the education of boys than of girls. This latter reason was hypothesised because it tied in well with the fact that a higher proportion of boys than girls are sent to private schools.

TRENDS IN SCIENCE CHOICE
(Academic or Vocational?)

In order to gain an insight into the trends in science subject choice, it is important to consider how the numbers of boys and girls opting to transfer to trade schools after two years in secondary schools changed over the period 1981-1990 (Table 2). Generally, the proportions of pupils in secondary schools and in

[22] MERCIECA, M.R., 'Factors Influencing Subject Choice...', op. cit.

trade schools are highly variable for both sexes. Most of the variation can be accounted for by changes in the structure of secondary education which were effected during the decade.

TABLE 2

Boys and girls in secondary schools (Sec.) and trade schools (TSc) during the scholastic years 1981-82 to 1989-90 (June figures)

YEAR		1982	1983	1984	1985	1986	1987	1988	1989	1990
BOYS	Sec	846	910	1351	550*	760	692	719	789	1061
	TSc	1276	970	867	1769	1354	1304	1299	1516	1003
GIRLS	Sec	1711	1654	2097	1809	1987	1424**	1419	1622	1935
	TSc	713	600	562	769	795	1293	645	592	528

*The opening of junior crafts centres for boys siphoned off many pupils from secondary schools. Their population is included with those of the trade schools.

**The opening of craft centres for girls had the same effect with the difference that many girls left school after a year in these centres.

When junior lyceums were established in September 1981, the trade school population of both boys and girls started to decline. This trend was reversed in the scholastic year 1984-85. During that year the number of boys opting for vocational courses doubled as junior craft centres were opened for them. An increase of thirty-six per cent over the previous year in the intake of girls in trade schools was also recorded in 1984-85. After 1985, the number of boys opting for trade schools and junior craft centres decreased but the number of girls choosing vocational courses continued to increase, rising particularly sharply in 1986 with the opening of junior craft centres for girls. During the scholastic year 1986-87 there were practically the same number of boys and girls in trade schools or junior craft centres. But with the difference that these figures represented approximately two thirds of all boys and only one half of all girls in government schools.

Physics - No Choice

During the period covering the scholastic years 1981-82 to 1989-90, physics was a compulsory subject, at first for part of the pupils but later for all pupils in secondary schools. Thus, during the first three scholastic years 1981-1984, physics was compulsory only for motivated or academically-oriented pupils. The other secondary school pupils had integrated science as a core subject.

During the scholastic year 1984-85, physics became compulsory for most pupils and by 1986-87 it was compulsory for all those in secondary schools. Since more girls than boys were identified as academically orientated and there were more girls in junior lyceums and secondary schools than boys, a much greater number of girls studied physics over the period indicated (Table 3 and Figure 1).

TABLE 3

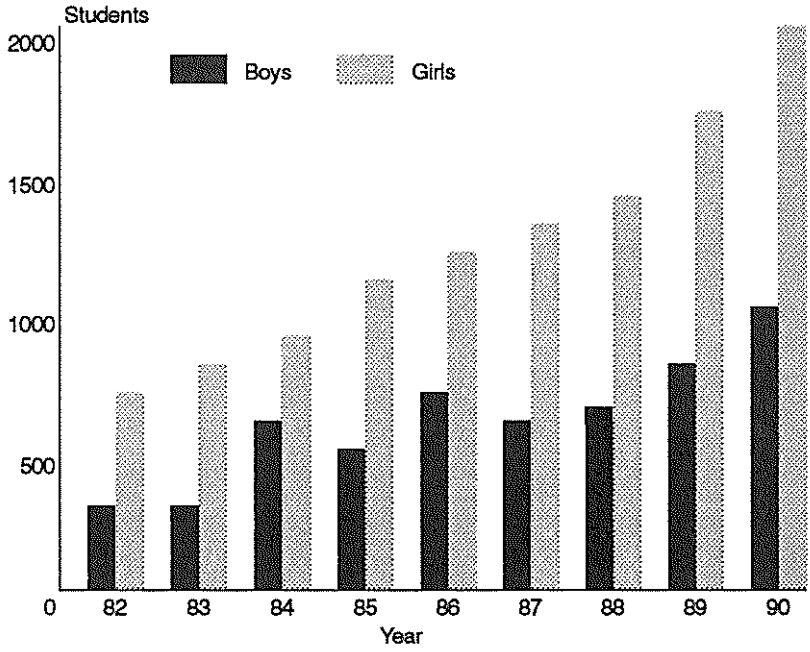
Numbers and percentages of boys and girls in government schools studying Physics in Form 3 during the period 1981 to 1990 (February figures).

		1982	1983	1984	1985	1986	1987	1988	1989	1990
BOYS	No.	434	425	553	540	746	697	719	789	1061
	%	20.5	22.6	24.9	23.3	35.3	34.9	35.6	34.2	51.4
GIRLS	No.	721	800	1035	1224	1292	1354	1419	1622	1935
	%	29.7	35.5	38.9	47.5	46.4	49.8	68.8	73.3	78.6

Besides the numbers of pupils who studied physics, it is interesting to note the percentages of the whole population of boys and girls in government schools. This statistic is important because one should remember that the pupils were following a GCE Ordinary level syllabus designed to challenge the top twenty-five per cent of the population. Considering that on average, since 1985 about one third of the boys and one half of the girls studied physics, it is doubtful what a large number of these pupils, especially girls, were understanding and one wonders what attitudes towards physics were being inculcated. A small-scale preliminary survey of attitudes towards physics conducted in 1986 among eighty boys and sixty-two girls in two government secondary schools showed that girls had a much lower positive attitude towards physics than boys.[23]

[23] BARTOLO, D., *Attitude to Physics Questionnaire,* unpublished B.Ed. (Hons.) dissertation, (Faculty of Education, University of Malta 1987).

FIGURE 1. CHOICE OF SCIENCE SUBJECTS AT FORM 3 LEVEL IN STATE SECONDARY SCHOOLS: Physics



Chemistry

Figure 2 shows the generally upward trend in the popularity of chemistry among boys and girls. Considering that fewer boys had the opportunity to choose the subject because many of them opted to go to a trade school, the popularity of chemistry among boys was high. In fact, between 1984 and 1990, an average of 34.3 per cent of all the boys attending government secondary schools and junior lyceums chose chemistry. The subject was much less popular among girls because over the same period only 9.8 per cent of those who had the opportunity to opt for chemistry did so. This agrees with the pre-1980 findings in the UK[24] but not with more recent UK figures which show that Chemistry is equally popular among the two sexes.[25]

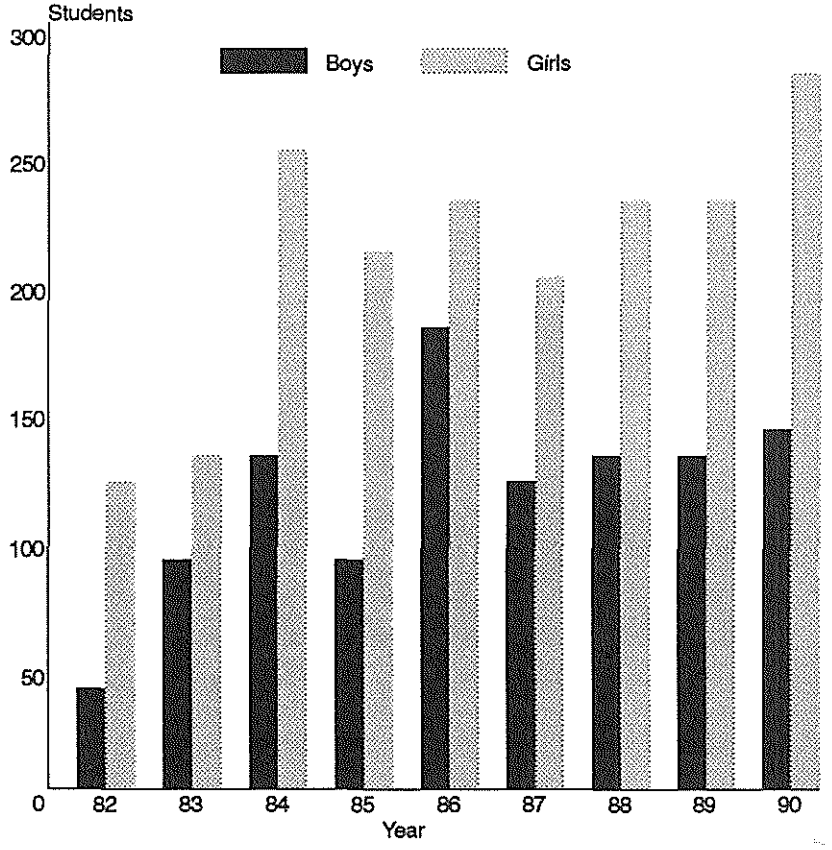
[24] GANNON, C., 'Girls' Underachievement in Science', op. cit.

[25] JOHNSON, S. & MURPHY, P., 'Girls and Physics' op. cit.

Biology

There was also a slightly upward trend during the period 1981-1990 in the number of boys and girls choosing biology

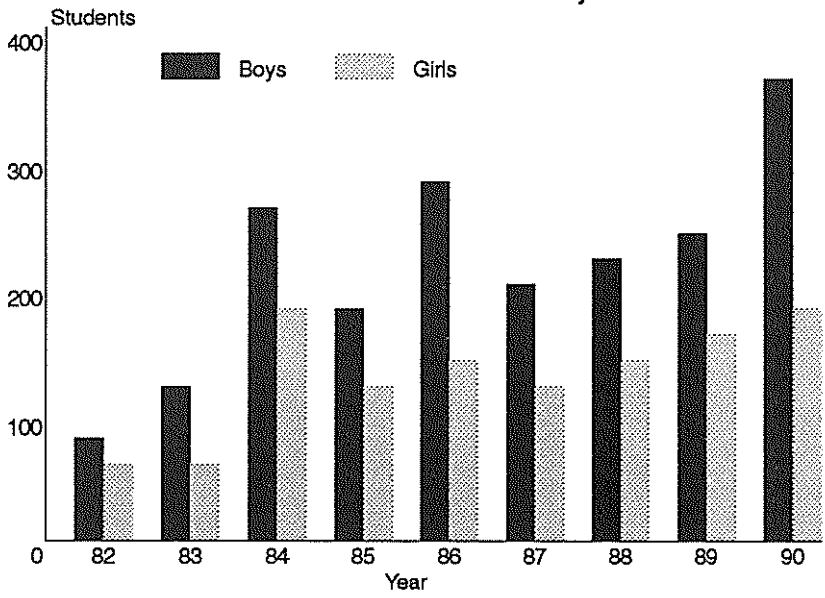
FIGURE 2. CHOICE OF SCIENCE SUBJECTS AT FORM 3 LEVEL IN STATE SECONDARY SCHOOLS: Biology



(Figure 3). In this case, considering the whole population, a higher percentage of girls than boys opted for biology. But considering that only pupils in junior lyceums and secondary schools had the opportunity to study the subject, it would seem that biology was more popular among boys. In fact, over the

period 1984 to 1990, 18.1 per cent of the boys and only 13.8 per cent of the girls decided to opt for the subject. This result does not agree with findings in the U.K. which show that biology is much more popular among girls. This unexpected result may be an artifact of statistics because of a larger number of girls in the secondary schools. But a study of girls' career aspirations and their perception of biology may reveal why the subject is not so popular.

FIGURE 3. CHOICE OF SCHIENCE SUBJECTS AT FORM 3 LEVEL IN STATE SECONDARY SCHOOLS: Chemistry



Private Schools

Physics was part of the compulsory core of the three boys' schools covered by the Private Schools Survey, but not in the three girls' school where it was optional. In fact, just 71.8% of the girls were studying the subject. Biology and chemistry were both taken by those pupils who opted for sciences. When the numbers of science and non-science boys and girls were compared only a slight but insignificant difference in favour of boys was found (χ^2= 0.93, p>.05). In other words there was practically no difference in the

proportions of private school boys and girls opting for science subjects (Table 4).

TABLE 4
Distribution of a sample of private school boys and girls among different options in February 1990

		Option 1	Option 2	Option 3
		Sciences	Commerce	Arts/General
BOYS	No.	150	190	22
	%	41.4	52.5	6.1
GIRLS	No.	95	120	40
	%	37.3	47.1	17.7

GENDER DIFFERENCES IN SCIENCE ACHIEVEMENT

Gender differences in performance in science have been investigated for some time. Almost invariably, the studies carried out so far have been based on the national annual examinations held in government secondary schools and junior lyceums. This means that the results cannot be generalized for the whole population since each private school holds its own separate annual examination. The only common examinations for government and private school pupils are the GCE Ordinary levels. However, only a fraction of boys and girls studying the subjects actually sit for the GCE examination. Any gender differences in performance at Ordinary level therefore apply to the select groups of pupils who sit for the GCE examination.

Science in Forms 1 and 2

Three studies of the national annual examination in Forms 1 and 2 held in government secondary schools have considered sex differences in performance in integrated science. Basing their study on the results of 1682 pupils in Form 1 and 1127 pupils in Form 2 who sat for their examination in June-July 1975, Falzon and Sammut found that the girls' performance was much higher than that of the boys and that the difference increased over the two years.[26] At the end of Form 2, an average girl's score was

[26] FALZON, J.M., SAMMUT, A., 'A Report on the National Examinations held in Government Secondary Schools (Form I to V) in June-July 1975', (Mimeo, Test Construction Unit, Education Department, Malta 1976).

equal to that of a boy in the seventy-fifth percentile. A similar result was obtained in a longitudinal study of a representative sample of 396 pupils (172 boys and 224 girls) in area secondary schools who sat for their examinations in June 1982 and June 1983. At the end of Form 1, the girls' mean score was five percentage points (one-third of a standard deviation) higher than that of the boys, and by the end of Form 2, this difference increased to nine percentage points (one-half a standard deviation).[27] The significance of these findings should be qualified by the observation that during the period of study, the population of the area secondary schools consisted of sixty-eight per cent of all girls and only fifty-nine per cent of all boys, the other pupils were creamed off to junior lyceums and private schools. The results of the June 1983 and June 1984 integrated science national examination of another representative sample of pupils (250 girls and 150 boys) in area secondary schools again showed the superiority of girls which increased over the two years. In this case it was also noticed that the differences were due to the performance in a small number of topics including: 'Classification', 'Heat', 'Atoms and molecules', 'Small organisms' and 'Body functions'. Moreover, when only the top twenty-seven per cent boys and girls were considered, the differences in performance vanished.[28]

Physics

Gender differences were also evident when performance in the separate sciences were considered. Apps showed that in the 1986 Form 4 national examination in physics for junior lyceum pupils, there was a significant difference in favour of girls (Girls: N=276, Mean=50.5; Boys: N=127, Mean=47.4; t=2.018, p.<05).[29] She

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[27] VENTURA, F., op. cit.

[28] AGIUS DELICATA, M., *Item and Error Analysis of the Integrated Science Examination Papers of Form I (1983) and Form II (1984)*, unpublished B.Ed (Hons.) dissertation, (Faculty of Education, University of Malta 1986).

[29] APPS, L., *Item and Error Analysis of a Form 4 Junior Lyceum Physics Examination*, unpublished B.Ed. (Hons.) dissertation, (Faculty of Education, University of Malta 1989).

noticed that boys did better in objective type questions ($p<.01$), girls performed better in the long questions ($p<.001$), while there was no significant difference between the scores obtained in structured questions. When the separate topics were considered, girls performed better in the topic 'Internal energy' while boys did better in 'Wave motion', the two sexes performed equally well in 'Mechanics'. An analysis based on the 1989 national annual

TABLE 5
National annual examination results June-July 1989

		BOYS			GIRLS				
Form	Sch.	N**	X**	SD**	N	X	SD	t-test	
PHYSICS									
3	JL*	530	49.0	14.9	831	54.6	11.7	7.702	p<.001
3	Sec*	200	38.6	15.5	690	36.1	13.1	2.276	p<.05
4	JL	360	47.9	18.8	630	40.1	16.9	6.730	p<.001
4	Sec	141	38.0	19.5	415	23.5	11.7	10.570	p<.001
CHEMISTRY									
3	JL	248	51.8	19.7	81	62.8	17.9	4.703	p<.001
3	Sec	27	37.1	14.3	35	35.9	14.4	0.311	p>.05
4	JL	177	55.2	20.3	115	57.3	19.5	0.875	p>.05
4	Sec	26	26.5	13.8	27	34.5	19.1	1.720	p>.05
BIOLOGY									
3	JL	122	74.6	14.6	159	74.6	13.6	1.177	p>.05
3	Sec	24	50.3	13.8	57	54.8	18.3	1.075	p>.05
4	JL	167	45.4	22.6	91	64.0	23.2	6.174	p<.001
4	Sec	16	35.8	11.7	50	23.8	14.7	2.925	p<.01

* JL = Junior Lyceum; Sec = Secondary School.
** N =Number of pupils; X = mean percentage mark; SD = Standard Deviation.

examination results (Table 5) however showed that the relative performance of boys and girls is variable. While Form 3 junior lyceum girls obtained significantly better scores than boys, the opposite was the case with Form 3 secondary classes and Form 4 junior lyceum and secondary classes. The general drop in the mean score from Form 3 to Form 4 should be noted. This is especially clear in the case of girls who constitute the great majority of pupils sitting for examinations. This result could be indicative of the waning interest in the subject between Forms 3 and 4. One wonders what benefit Form 4 secondary school girls

derive from compulsorily studying a subject in which their score is only 23.5 per cent averaged over more than four hundred individuals.

Chemistry

A study of the 1983 Chemistry national examination for Form 3 junior lyceum pupils which considered the whole population showed that there were no gender differences in overall scores as well as in the scores of each of the three separate sections of the examination paper, which consisted of objective type, structured and long questions.[30] The analysis of the June 1989 results (Table 5) confirmed this finding, except for the Form 3 junior lyceum examination in which girls were superior to boys. In this case the relatively small number of select girls studying the subject could have biased the result in their favour. The other results which were based on samples of comparable size were more indicative of the equal performance of the sexes in chemistry.

Biology

Girls surpassed boys in the 1985 Form 3 national examination for junior lyceum students. The detailed analysis of the scripts of that examination showed that girls did better in the objective type and short-answer questions while there was no difference between boys and girls in the long answer section of the paper.[31] The girls' superiority in biology was again demonstrated in the 1989 Form 4 national examination for junior lyceums (Table 5), but not in the Form 3 examinations of the same year, where no significant gender differences were found. Furthermore, Form 4 secondary school girls performed very poorly. Their average mark (23.8 per cent) was as low as that in physics (23.5 per cent), while the number of girls studying biology was comparatively small.

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[30] ZAMMIT, J., *The Form 3 Chemistry Junior Lyceum Annual Examination Paper, July 1983: A Study,* unpublished B.Ed. (Hons.) dissertation, (Faculty of Education, University of Malta 1986).

[31] VELLA, A., *Item and Error Analysis of the Biology Examination Paper for Form 3, 1985,* unpublished B.Ed. (Hons.) dissertation (Faculty of Education, University of Malta 1988).

From the results of the national examinations, it is possible to conclude that girls in junior lyceums perform just as well, and sometimes better than boys in each of the separate sciences. This is also the case in integrated science in secondary schools. But the comparatively small number of boys who study physics in secondary schools perform significantly better in this subject than girls both in Form 3 and Form 4. In chemistry and biology the performance of boys is on a par with that of girls at Form 3 level. The Form 4 girls' scores in biology and physics are unexpectedly low, considering the corresponding Form 3 scores. Loss of interest in the subjects, inability to cope with the increasingly difficult GCE Ordinary level work and loss of self-confidence may be contributing to these results.

PERFORMANCE AT GCE ORDINARY LEVEL

The results of the previous section refer only to pupils in government schools. As yet, no common examinations or tests in physics, chemistry and biology have been held for pupils in government and private schools during their secondary education. The first common examination for these pupils occurs when they sit for GCE Ordinary level examinations. However, only a fraction of those studying the subjects actually sit for the examination and this places a limitation on the possibility of generalizing on gender differences noted in Ordinary level results. Maltese pupils usually sit for the Ordinary level examinations of one or more of the following GCE boards: London, Oxford and AEB. Where possible, many pupils sit for the same examinations with different boards during the same session of examinations. The compounded results of the three boards therefore result in double counting of candidates. Additionally, many Form 4 and Form 5 pupils attempt the Ordinary level examination well before they finish their course at school and their results may confound any gender differences in performance. In order to reduce the effect of these factors, only the data from the June sessions of the London GCE board were considered. The London board was chosen because it was the most popular among candidates sitting for science examinations and because its accessible results differentiated between males and females in private and government schools. Another reason was that previous work had been carried out on selected results of

examinations of the same board held between June 1975 and June 1978. This work concluded that there were no gender differences in achievement in chemistry and biology, though boys obtained better pass grades in chemistry. In physics, boys fared much better than girls. In fact forty-six per cent of the boys as against twenty-two per cent of the girls obtained a pass. It was also noted that fewer girls than boys (ratio 1:2) sat for science examinations.[32]

Ordinary Level Physics

After 1979 when physics was introduced as a compulsory subject for Form 3 and older students in government secondary schools, it was expected that more candidates would sit for the physics Ordinary level examination in June 1982. Even more so because physics was a requirement for entry to the government sixth form where students were eligible for the monthly allowance of a pupil-

TABLE 6
Physics London GCE O Level results (June sessions) for 1980 to 1983

	1980			1981			1982			1983		
	Sat	Pass	%	Sat	Pass	%	Sat	Pass	%	Sat	Pass	%
MG	104	29	28	80	28	35	147	50	34	192	74	39
FG	44	21	43	39	21	54	162	54	33	215	51	24
MP	73	25	34	81	40	47	113	45	40	148	49	33
FP	8	3	38	14	10	63	8	2	25	18	7	39
ML	23	8	35	25	11	44	20	8	40	37	12	32
FL	6	2	33	7	2	29	6	1	17	12	2	17
TOTALS												
M	200	62	31	186	79	43	280	103	37	375	135	36
F	58	26	45	60	33	55	176	57	32	245	60	25

M = Males; F = Females; G = Government Schools; P = Private Schools; L = Left school

worker. The results of the Ordinary level examinations for the years 1980 to 1983 were considered in order to gauge the effect of

[32] VENTURA, F., 'Sex Differences in Science Achievement at G.C.E. O-Level' *Education*, vol.1 no.1 (Malta 1982) pp. 3-4.

compulsory physics (Table 6), as well as the results of the January 1990 session to check for the continuation of any trend noticed in the former results.

The data in Table 6 show that in every year more boys than girls sat for the examination, but while the ratio of boys:girls was 3:1 in 1980 and 1981, this fell to 3:2 in 1982 and 1983. This change probably indicates that the effect of compulsory physics began to be felt in 1982 as expected. However, it appears that while the boys' pass rate over the four year period did not differ much from the average rate of about thirty-six per cent, the girls' pass rate dropped drastically from an average of fifty per cent to a low of 24.5 per cent in 1983. A chi square test on the number of passes and failures of boys and girls indicates no sex differences in 1980, 1981 and 1982 but a definite difference in favour of boys in 1983. The trend in the increase in numbers of pupils sitting for physics Ordinary level is confirmed by the January 1990 results (Table 9). In that session, practically equal numbers of boys and girls sat for physics, but the pass rate for boys was definitely much better.

The 1980-1983 results reveal another sex difference since it appears that while boys in private schools reacted immediately to the compulsory physics requirement for entry to the government sixth form, as shown by the increase in the numbers of private school boys sitting for physics in 1982 and 1983, private school girls did not react likewise. However, by 1990, the number of female private school candidates had increased enormously and their pass rate had improved, along with that of all other categories of pupils.

Assuming that the standard required for a pass in physics Ordinary level did not fall from 1983 to 1990, it is safe to conclude that knowledge of physics at Ordinary level is much more widespread now than it was before 1982. Academically-orientated girls benefited more than boys by the introduction of compulsory physics as evidenced by a comparison of the number of candidates and percentage passes of the June 1982 and the January 1990 results, even though their performance did not match that of the boys.

Ordinary Level Chemistry

Similarly to physics, chemistry was more popular among boys (Table 7 and Table 9). Except for the differences in the number of boys and girls sitting for the examination, there was no significant sex difference in the pass rate in all the examination sessions. Overall it should be noted that the number of pupils sitting for chemistry did not change drastically from 1983 to 1990, except for a definite increase in the number of candidates from private schools for girls.

TABLE 7
Chemistry London GCE O Level results (June sessions) for 1980 to 1983

	1980			1981			1982			1983		
	Sat	Pass	%	Sat	Pass	%	Sat	Pass	%	Sat	Pass	%
MG	35	16	46	28	14	50	28	14	50	75	41	55
FG	46	19	41	28	17	61	46	29	63	55	33	60
MP	45	26	58	40	20	50	43	23	54	59	24	41
FP	10	3	30	8	5	63	4	1	25	8	4	50
ML	8	4	50	1	1	100	5	2	40	7	2	36
FL	3	0	0	4	2	50	4	0	0	0	0	0
TOTALS												
M	88	46	52	69	35	51	76	39	51	141	67	48
F	59	22	37	40	24	60	54	30	56	63	37	59

Ordinary Level Biology

Rather unexpectedly, biology was also more popular among boys as a subject to be taken at Ordinary level between 1980 and 1983 (Table 8). The balance was redressed in 1990 as the number of private schools for girls offering the subject increased considerably (Table 9). Chi square tests on the number of passes and failures did not indicate any significant sex differences in performance in biology in all sessions.

SCIENCE CHOICE IN THE SIXTH FORM

Over the period 1980-1990, an increasing number of students decided to continue with their studies at the sixth form. Although more boys than girls took this route, the difference between them is not very big as can be deduced from Figure 4. The graph shows

only those students attending the government sixth form. A much smaller number of students joined sixth forms in private schools during the same period. On joining the sixth form students make

TABLE 8
Biology London GCE O Level results (June sessions) for 1980 to 1983

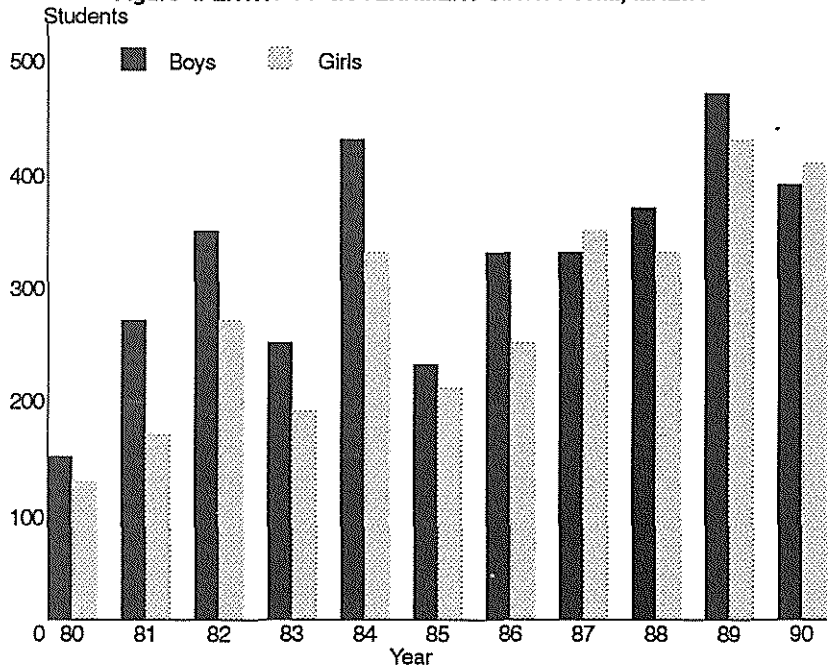
	1980			1981			1982			1983		
	Sat	Pass	%	Sat	Pass	%	Sat	Pass	%	Sat	Pass	%
MG	63	19	30	26	6	23	24	6	25	42	21	50
FG	82	21	26	72	32	44	74	32	43	76	22	29
MP	128	44	34	99	46	47	133	51	45	162	58	36
FP	17	4	24	11	6	55	19	6	32	11	5	46
ML	16	6	38	11	6	55	6	1	17	6	2	33
FL	6	1	17	12	4	33	4	2	50	3	1	33
TOTALS												
M	207	70	34	136	58	43	163	64	39	210	81	39
F	105	26	25	95	42	44	87	37	43	90	28	31

TABLE 9
London GCE O Level Science results for the January 1990 session

	PHYSICS			CHEMISTRY			BIOLOGY		
	Sat	Pass	%	Sat	Pass	%	Sat	Pass	%
MG	291	190	65	67	53	79	42	28	67
FG	448	210	47	37	29	78	69	29	42
MP	365	169	46	75	58	77	49	30	61
FP	232	137	59	52	43	87	83	53	64
ML	186	106	57	20	13	65	31	5	16
FL	161	48	30	18	12	67	32	6	19
TOTALS									
M	842	465	55	175	124	71	122	63	52
F	841	395	47	107	84	79	184	88	48

a choice of three subjects to study at A-level. At this point some advice about subject choice is tendered to students and parents. But, especially in the case of science students, the choice is usually predetermined by success in Ordinary level examinations and by the students' aspirations for a university course or a job.

Figure 4. ENTRY TO GOVERNMENT SIXTH FORM, MALTA



Students aiming at joining the medical course or a similarly orientated course (dentistry, nursing, pharmacy) usually opt for biology, chemistry and physics. Those aspiring for a career in engineering or architecture usually choose mathematics and physics. Students who wish to specialize further in science or who wish to take up a teaching career in science opt for a choice which includes biology, chemistry, physics or mathematics. These are not the only possible options, but for students wishing to pursue scientific studies, physics is practically seen as a core subject. Consequently almost all science students at the sixth form opt for physics.

Considering the period 1980 - 1990, it is interesting to note that the popularity of physics increased both in the case of male and female students (Figure 5). However, there is a difference between them because while an average of 56.5 per cent (range ±8.8 per cent) of all boys joining the government sixth form opted for physics, only an average of 31.4 per cent (range ±8.8 per cent)

of all girls did so. This difference can be explained by analyzing the choice of biology, chemistry and mathematics over the same period since these subjects are usually studied along with Physics (Figures 6, 7, 8). The graphs show that, while approximately equal numbers of boys and girls opted for biology and chemistry, the number of girls choosing mathematics remained very low throughout while a proportionately large number of boys studied the subject. In fact over the eleven year period, an average of 30.8 per cent (±6.6 per cent) of all boys in the sixth form studied mathematics as compared to 7.1 per cent (±3.9 per cent) of all girls. A reason for this discrepancy could be that very few girls aspired for a career in engineering and technology. Some evidence for this reason can be found in the statistics of university students in related courses. Thus, in February 1987, five year groups in the Faculty of Architecture and Engineering had between them eighty-six male and six female students following the course in architecture, 114 males and eight females in the electrical engineering course, and 111 male and four females in the mechanical engineering course.[33]

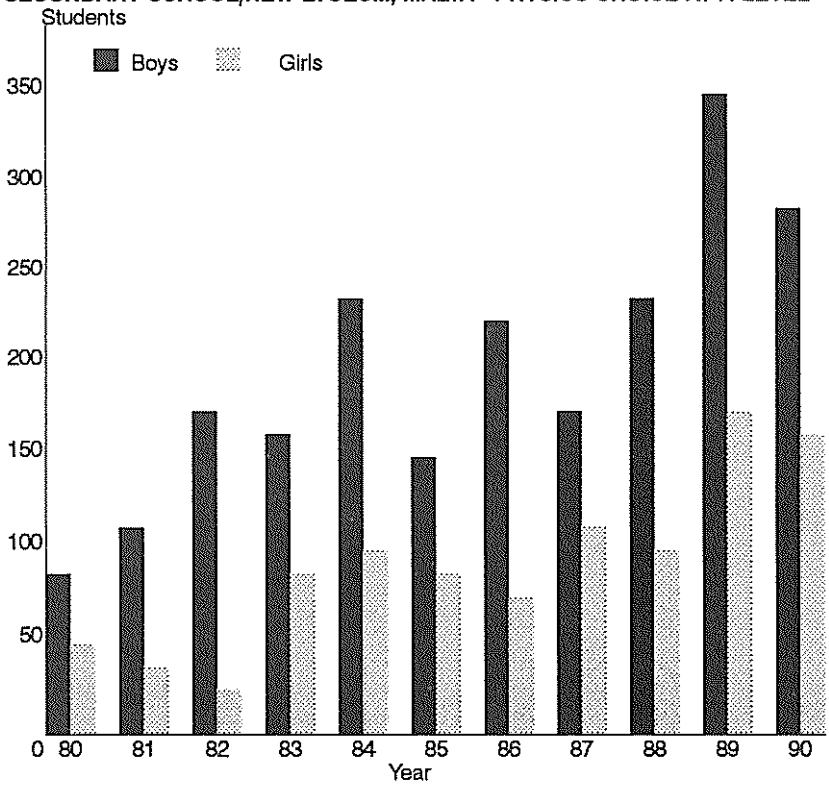
Biology and Chemistry are equally popular among male and female students and their popularity shows a general increase (Figures 6 and 7). On average twenty-seven per cent (±6.9 per cent) of all boys and 27.1 per cent (±4.7 per cent) of all girls at the sixth form opted for chemistry while 23.9 per cent (±6.9 per cent) of all boys and 25.3 per cent (±3.2 per cent) of all girls studied biology at A-level. It is therefore not surprising that, in April 1988, for the first time in our university, an equal number of male and female students graduated in Medicine. There is no reason why this trend should not continue as long as girls take up the opportunities that our society offers them.

CONCLUDING REMARKS

Considering the data presented in this study, it is now possible to comment on whether the Maltese educational system at secondary level has managed to avoid sexual discrimination in science

[33] *University of Malta Gazette* vol.19 no.2 (University of Malta, June-July 1987), pp.19-21.

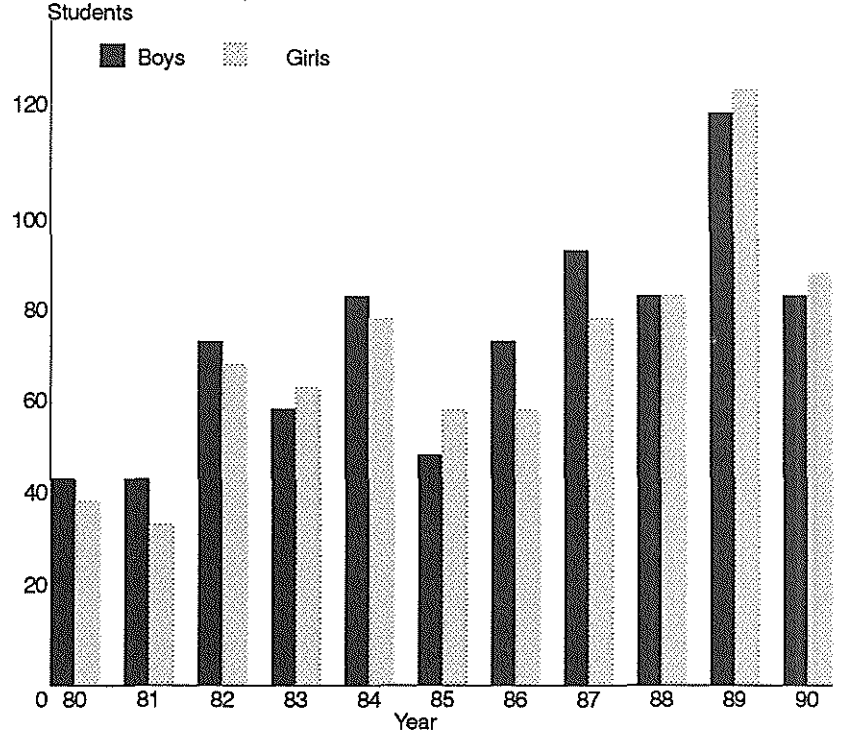
Figure 5 CHOICE OF SUBJECTS AT PRESENT SIXTH FORM LEVEL, UPPER SECONDARY SCHOOL/NEW LYCEUM, MALTA - PHYSICS CHOICE AT A-LEVEL



education and to ensure an equitable female representation in certain fields of higher education, particularly in scientific and technical areas.

In the first two years of the secondary school there are no differences in opportunity for boys and girls to study science either in government schools or private schools. All schools offer an integrated science course for 11-13 year-olds. Teachers, laboratories and other facilities are available for both sexes without any distinction. At this stage of education, all the evidence available shows that in fact girls perform better than boys in science examinations.

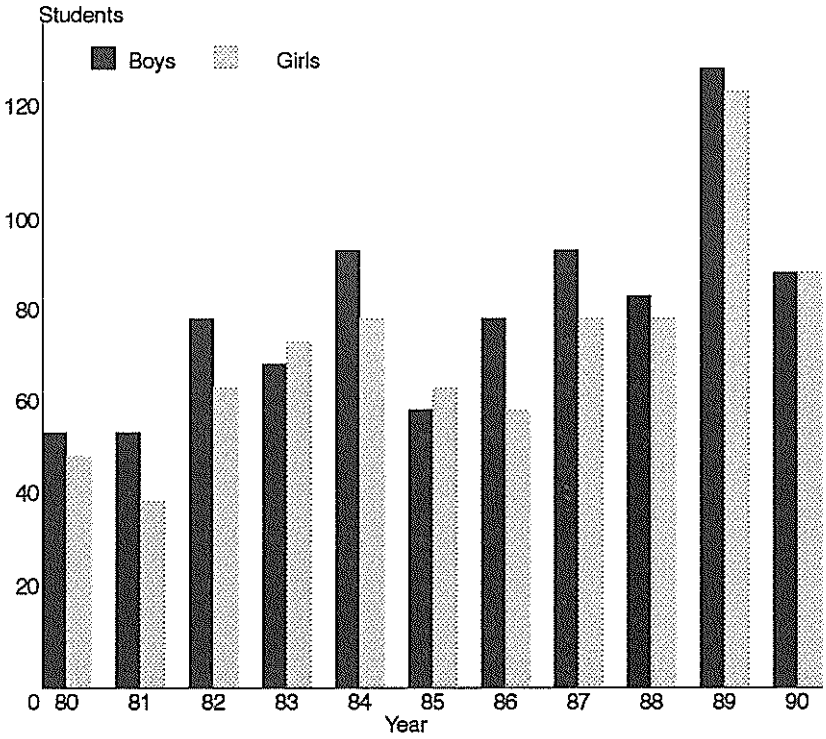
Figure 6. CHOICE OF SUBJECTS AT PRESENT SIXTH FORM LEVEL, UPPER SECONDARY SCHOOL/NEW LYCEUM, MALTA - BIOLOGY CHOICE AT A-LEVEL



After the second year, physics becomes a core subject for all students in government secondary schools, except for those in Trade Schools. Because fewer girls opt to go to Trade Schools, many more girls than boys have the opportunity to study physics, in fact the ratio of girls to boys studying physics has been in the region of 2:1 for the past ten years. In the case of the private schools, the situation is not as favourable for girls. As shown by the Private School Project, while all the boys attending these schools have physics as a core subject, nearly thirty per cent of the girls do not study the subject and may in fact have no science at all from the third year onwards.

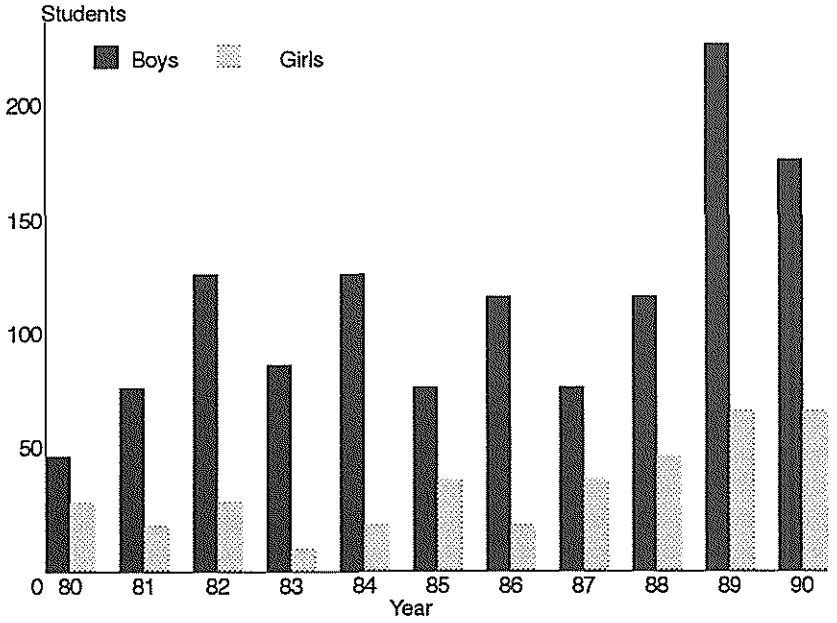
In government schools at the end of the second year the students' choice of options is entirely free, though aided by advice from guidance teachers and others. When considering chemistry

Figure 7. CHOICE OF SUBJECTS AT PRESENT SIXTH FORM LEVEL, UPPER SECONDARY SCHOOL/NEW LYCEUM, MALTA - CHEMISTRY CHOICE AT A-LEVEL



and biology separately, it is found that far more boys opted for chemistry while more girls opt for biology, though percentage wise boys predominate in both subjects. One reason for these differences is partly due to the different way the options are presented to boys and girls. While boys can take chemistry with either biology or graphical communication (technical drawing), girls can only take chemistry with biology. On the other hand, while boys are only allowed to take biology with chemistry, girls may take biology with either chemistry, home economics or needlecraft. The different ways that options are offered are probably due to the underlying mistaken belief that biology is more likely to be useful to girls and chemistry to boys.

Figure 8. CHOICE OF SUBJECTS AT PRESENT SIXTH FORM LEVEL, UPPER SECONDARY SCHOOL/NEW LYCEUM, MALTA - MATHEMATICS CHOICE AT A-LEVEL



The achievement of both sexes in biology and chemistry is practically the same in the national annual examinations and at GCE Ordinary level. The physics results show otherwise. Although over the years the number of girls studying the subject has increased, their performance is still lower than that of boys especially at GCE Ordinary level. These results are similar to those obtained in other countries which have a different organization of secondary education. This leads to the suggestion that the differences in achievement of boys and girls in physics is independent of educational context and probably due to intrinsic differences between the two sexes and to different socialization patterns. Still, results in junior lyceum examinations show that girls can perform better than boys in physics on some occasions. A closer analysis of these occurrences is needed to point out how these girls managed to achieve as well as their male counterparts.

After the lower secondary school, the next step leading towards a scientific or technical career is the choice of subjects to study at A-level. At this stage, while approximately equal numbers of boys and girls choose biology and chemistry, a significantly lower proportion of girls choose physics. The difference can be accounted for by the far larger number of boys who choose physics with mathematics. In fact the proportion of girls choosing to study mathematics at A-level is very low. Considering that many girls obtain high grades in mathematics at Ordinary level, this flight from the subject is not easy to explain. But a reason which is supported by data from University course intakes could be that girls avoid careers in engineering and technology, for which mathematics is compulsory, and prefer careers in medicine and related subjects instead.

Because at this crucial upper secondary stage girls appear to shun the choice of mathematics with physics, female representation in scientific and technical areas will continue to be low. Thus, for a long time to come, Malta would probably fit into Ruivo's 'less developed group' in which the percentage of female scientists and engineers in the country can be between 2.5 per cent (as in Madagascar) and 9.3 per cent (as in Togo). In this respect we would be far removed from the 'semi-industrialized group' which has a female representation of about 24 per cent (as in Singapore) to 36.6 per cent (as in Portugal) up to as high as 56.8 per cent (as in Argentina).[34] Thus in spite of avoiding blatant sexual discrimination in science education statutorily at the secondary school level, it seems that some positive action needs to be taken at the higher level to attract more girls to careers in science and technology.

[34] RUIVO, B., 'The Intellectual Labour Market in Developed and Developing Countries: Women's Representation in Scientific Research', *International Journal of Science Education* vol.9 no.3 (1987) pp. 385-392.